Project B-226

ELECTRONIC TESTING AND MEASURING INSTRUMENTS
A MANUFACTURING OPPORTUNITY IN ATLANTA

Prepared for

FORWARD ATLANTA
The Atlanta Chamber of Commerce

by

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Foreword

An unusual combination of assets, ranging from relatively low production labor costs to the exceptional combination of research and educational resources, makes Atlanta a logical location for manufacture of electronic testing and measuring instruments.

This report, the eighth in this particular series of technical reports, will likely be followed by additional analyses of the types of manufacturing operations which should find Atlanta's educational and research complex especially valuable.

Inquiries regarding this study or requests for comparable analyses of other product complexes will be welcomed.

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Summary

Atlanta's research facilities, pool of technical personnel, and air transportation network make it a suitable location for the manufacture of electronic testing and measuring instruments. The city can do more than meet these basic requirements for successful operation, however; manufacturers can expect profits 49 to 71% higher in Atlanta than in Chicago or New York, due primarily to the city's comparatively low production labor costs.

The Georgia Tech Engineering Experiment Station performs $4 million worth of research annually--almost $1 million of that total in electronics. Major research capabilities exist in such diverse areas as network theory, automatic controls, radar, microwaves and communications. Several electronics companies, an aircraft plant, and a major medical research complex in Atlanta also conduct research programs relative to electric and electronic measuring devices.

The 19 degree-granting colleges and universities in metropolitan Atlanta, together with the area's growing technical and vocational school complex, provide business and industry with a large and continuing supply of well qualified graduates. Georgia Tech will grant more than 200 degrees in electrical engineering and physics in 1962 and approximately 1,000 degrees in other areas of science and technology. Southern Technical Institute graduates approximately 280 technicians each year in 11 areas of technology, including three options in electrical technology.

Atlanta is one of the few cities in the nation which can meet this industry's requirements for efficient air transportation to customers scattered throughout the country. Only four cities--Chicago, Los Angeles, New York and Washington--had more airline departures than Atlanta in 1961. A total of 54 cities are served by non-stop flights from Atlanta. Some 19 cities are served by pure jets, and another 25 are served by prop jets, all without a change of planes.

Purely economic considerations, however, make Atlanta more attractive for the manufacture of electronic instruments than any of the major cities which presently dominate the industry. The most significant strictly economic factor is the cost of production labor, which comprises more than 20% of the total value of products shipped. A plant producing annual shipments valued at $6,000,000 could expect the following production labor

costs in Atlanta and in the two major producing areas with the lowest wage rates:

Atlanta	$ 997,000
Chicago	1,293,000
New York	1,420,000

Atlanta's shipping cost disadvantage to national markets (versus Chicago and New York) is small and is virtually offset by lower utility costs in Atlanta. Additional initial savings would accrue from Atlanta's lower construction costs--40% lower than in New York and 20% lower than in Chicago.

A bonus attraction for a plant in the Atlanta area is the growing market for electronic instruments in the Southeast. Atlanta is strategically located in relation to the government's defense and space installations in the Southeast and the Gulf Coast. Markets are also expanding in the area with the growth of electronics manufacturing companies, transportation equipment manufacturers, and communications and utilities companies and with the increasing use of electronic instruments in the traditional industries in the Southeast.

INTRODUCTION

Three factors are usually considered essential for the successful operation of an electronic testing and measuring instruments plant. They are: (1) access to research facilities, (2) availability of a pool of trained technical personnel, and (3) proximity to a nation-wide air transport network.

This combination of requirements has caused most of the instruments industry to build plants in large metropolitan areas. In fact, over half of the U. S. production takes place in just four urban areas--Boston, Chicago-northwestern Indiana, New York City-northeastern New Jersey, and Los Angeles-Long Beach, California.

From a purely economic standpoint, however, most metropolitan areas have one serious drawback--high production labor costs. This is particularly true in the four areas mentioned above. The significance of this factor is reflected in the fact that the cost of production labor--comprising more than 20% of the total value of products shipped--is by far the most important input in the manufacture of electronic testing and measuring instruments.

This study was undertaken because it was felt that Atlanta can combine the three advantages of a large metropolis with lower production labor costs. Analysis was begun by procuring information on all of the purely economic factors. Local sources of raw materials were sought. Utility and production labor costs for Atlanta and the other four areas were investigated. Outbound shipping costs to national markets from a hypothetical plant at each location were compared. These preliminary steps showed that far more money could be made by serving the national market from Atlanta than from any of the other four national cities.

At this point both Boston and Los Angeles were dropped from the study so that the comparisons between Atlanta, Chicago and New York could be refined. As a national distribution center, Boston is less desirable than New York, and Los Angeles is less desirable than Chicago. More important is the fact that both Boston and Los Angeles have higher production wage rates than either Chicago or New York. According to the 1958 Census of Manufactures, the average hourly production wage paid by the electrical testing and measuring instruments industry (SIC 3611) in each of the four cities was as follows:

Boston	$2.45 per hour
Chicago-northwestern Indiana	$2.23 per hour
Los Angeles-Long Beach	$2.40 per hour
New York City-northeastern New Jersey	$2.24 per hour

This analysis, therefore, compares the locational advantages of Atlanta with those of the two major producing areas which are most competitive in terms of national market orientation and production labor costs.

I. CHARACTERISTICS OF THE INDUSTRY

A wide variety of electronic products, both industrial and military, may be included in a product segment labeled "testing and measuring instruments." Products most often placed in this group include broadcast test equipment, instrument calibrators, engine analysers, frequency or waveform measuring equipment, microwave test equipment, oscilloscopes, and various recording devices. The products most often placed in this group are listed in Table 1.

Table 1

ELECTRONIC TESTING AND MEASURING INSTRUMENTS

Product	Sales (millions of dollars) 1961	1962	1965
Spectrum Analyzers	8	10	15
Signal Generators	50	60	75
Oscilloscopes, high-frequency	34	36	40
Oscillographs and other Oscilloscopes	10	12	15
Voltage, Current and Power Measuring	15	16	20
Components Testers (tube, transistor, etc.)	17	17	18
Calibrators, Instrument	25	26	28
Electronic Timers	8	8	10
Bridges and Decades	10	10	10
Frequency Measuring	18	19	20
Waveform Measuring	18	20	21
Impedance and SWR	3	5	6
Frequency Meters	32	34	35
Recording Instruments	28	30	40
Engine Analyzers	25	27	30
Radiometers	3	5	10
Panel Meters, Indicating	18	21	30
Broadcast Test Equipment	2	3	5
Power Supplies, Laboratory	40	50	75
Active and Passive Networks	5	6	10
Microwave Test Equipment	15	17	20
Spectrometers	15	20	30
Infrared Detectors	20	25	50
Digital Readout Devices	30	36	70

Source: "Our Growing Markets," Electronics, McGraw-Hill, January 5, 1962.

The electronics industries shown in Table 2 have production and marketing requirements which are similar to those for the testing and measuring equipment industry, so most of the discussion in this report is also applicable to them. The historical and projected annual sales figures in the tables illustrate a common denominator of all of the industry groups listed--rapid growth.

Table 2

SIMILAR ELECTRONICS INDUSTRIES

Industry	Sales (millions of dollars) 1961	1962	1965
Department of Defense and National Aeronautics and Space Administration Electronics	7,500	9,458	12,220
Industrial Control Systems	171	189	275
Medical Equipment	63	75	98
Nuclear Instruments and Controls	85	113	149

Source: "Our Growing Markets," Electronics, McGraw-Hill, January 5, 1962.

Another common factor is a high rate of expenditure for research and development. Government contracts are a major source of funds, but the industry itself sponsors a significant amount. Research by manufacturers tends to be highly specialized. Consequently, even long-established manufacturers draw upon the capabilities of research groups which are not a part of the company in order to solve problems outside of their areas of specialization. This is one reason why manufacturing has developed in urban areas with established research facilities. In addition, public research facilities are frequently sources of new or improved products.

In order to keep up with rapidly developing technology, individual firms maintain a high ratio of engineers and scientists to production personnel. In some plants working on military products the ratio may be as high as 1:2, and one engineer for every three production personnel is normal. The need for engineers has a strong influence on plant location. It is often necessary to locate a plant in a congested metropolis rather than in

a small community in order to be able to draw upon the pool of engineers concentrated in the urban area. Technical personnel have shown preference for locations near educational institutions offering graduate study for professional advancement and for the cultural advantages which are found in large cities.

Rapid technical evolution results in a correspondingly rapid obsolescence of electronic instruments. For this reason, marketable products must be introduced quickly, often while still in the design stages. Close personal communications between buyer and seller are essential. Consequently, access to a network of daily air routes is another basic requirement for a successful manufacturing operation.

The manufacturing process itself is characterized by low investment in raw materials and production equipment and a high value added by labor. Production quantities are low, so that expensive automated equipment is not justified. Wages for production workers alone account for more than 20% of the value of the product. Shipping costs, which are a prime location factor for many industries, are unimportant for manufacturers of electronic testing and measuring equipment.

Communities in which this industry has located and grown have three assets in common: (1) they have electronics research facilities; (2) they are attractive to and provide a reservoir of trained technical personnel; and (3) they provide easy access to national markets through air transportation.

In different proportions for different companies, these three factors are basic requirements for most successful operations. Other considerations are labor costs, construction costs, proximity of raw materials, freight costs, utility costs, and accessibility to special markets. Of the strictly economic factors, the cost of production labor has the greatest effect on profitability.

II. ATLANTA'S ELECTRONICS RESEARCH FACILITIES

The Georgia Tech Engineering Experiment Station performs $4 million worth of research annually--almost $1 million of that total in electronics. Several private companies, an aircraft plant, and a major medical research complex in Atlanta also conduct research programs relative to electric and electronic measuring devices.

The research staff of 650 employees at the Engineering Experiment Station is built around 300 experienced scientists and engineers. Approximately 200 of these devote full time to research, while the remaining 100 divide their time between teaching and research. They are supported by qualified technical assistants, machinists and technicians, all under centralized administrative direction. Facilities are available for research in most phases of science and engineering. The services of these personnel and facilities are available on a consultation or contract basis through the Georgia Tech Research Institute.

Research in electrical engineering at Georgia Tech includes such diverse areas as network theory, automatic controls, electromagnetic theory, communication circuits, and instrumentation. Facilities and qualified personnel are available in most of the other important areas of electrical machinery and systems, particularly electronics.

Major electronics research capabilities exist in the areas of radar, microwaves, and communications. Facilities include two field sites for propagation links, HF and VHF antenna ground plane and vehicular laboratories, a microwave test range, and well-equipped frequency control, electronic, microwave and interference measurements laboratories.

Programs in radar, encompassing the fields of information theory, ultra-narrow-beam antennas, and millimicrosecond pulse techniques, have produced designs for several new types of radar systems. Some of these systems have been completely developed and evaluated under field conditions by Georgia Tech personnel.

Microwave research efforts have included work with devices for high resolution radar and radiometer systems and research directed toward increasing the sensitivity of microwave spectrometers. Some of the major subareas have been shaped-beam antennas, geodesic lenses, ring switches, millimeter wave techniques, and ferrite devices.

In the area of communications, advanced techniques for both FM and AM modulation and detection have been developed. They include suppressed-carrier systems which are insensitive to the Doppler Effect and can consequently provide power-conserving voice communications for high-velocity aircraft. Extensive research activities in frequency control have resulted in improved techniques for fabrication and utilization of quartz crystals and have produced crystal-controlled oscillations with frequencies up to 600 megacycles.

Representative of work on RF interference is a comprehensive research program to develop electronic computer techniques for assigning frequencies and equipments to army field communication systems on a non-mutual interference basis. This program includes studies to determine the interference susceptibility and emanation characteristics of transmitting and receiving equipment, as well as methods for computing optimum allocations of this equipment and its frequencies within an arbitrary communication system.

Following the pattern set at Massachusetts Institute of Technology, Stanford University, California Institute of Technology and many other campuses, new research-based companies have been established by former personnel of Georgia Tech's Engineering Experiment Station. Most are based upon instrumentation technology. The foremost example of this is Scientific-Atlanta, Inc. This company, created in 1952, now has about 225 employees and over $3 million annually in sales. It claims to be the leading specialist in the antenna instrumentation field, furnishing well over half the instruments used in this activity. It also has developed other new products, such as a B-H meter for testing magnetic tape which is now used by most major tape manufacturers.

Emory University spends approximately $2.5 million per year on research, primarily in the medical field. This effort is closely meshed with that of the Communicable Disease Center, which has an estimated research budget of $6 million per year. The Center is consolidating its national operations in Atlanta and is building extensive research facilities adjacent to the Emory campus. The relatively new field of medical electronics is an important element of the research being done in the CDC-Emory complex. The Special Problems Branch of Georgia Tech's Engineering Experiment Station works with the complex in medical electronics. For example, the Branch has designed and built analogue computing devices for continuous processing and data

reduction of blood pressure, heart rate, and electro-encephalographic signals.

Private companies performing in related fields include RMS Engineering, Inc. (formed by Engineering Experiment Station personnel), which specializes in the development of precision radio receivers; Lockheed-Georgia Company at Marietta, which is concerned with aircraft instrumentation and airframe testing equipment; Radiation Technology, Inc., which produces transistorized instruments for the measurement of radiation; and Aeroscience Electronics, Inc., which specializes in telemetry systems.

Perhaps most important, the recently announced location of a major electronics facility in DeKalb County by Litton Industries, not far from the new plants built by Scientific-Atlanta and Theta Electronics of Georgia, Inc., gives promise of a new technology-oriented center in the Atlanta area.

III. ATLANTA'S RESERVOIR OF TECHNICAL PERSONNEL

Companies like Lockheed-Georgia and Scientific-Atlanta and the local operations of the Bell Telephone System rely heavily on personnel trained at the Georgia Institute of Technology. More than 6,200 known Georgia Tech alumni reside in Atlanta.

Seven other fully accredited universities and colleges in Atlanta offer degrees in electrical engineering or physics. In addition, nine vocational and technical schools offer courses in drafting, electrical technology or electronic technology.

Georgia Tech is the most widely known institution in Atlanta's educational complex. It has approximately 6,700 students enrolled in college day courses, with 4,800 in various evening school programs. In calendar 1962, 1,028 students will be graduated with Bachelor of Science degrees, 183 with Master of Science degrees, and 43 with Doctor of Philosophy degrees. A total of 202 degrees in electrical engineering and physics are expected to be granted during the year, as follows:

	BS	MS	PhD
Electrical Engineering	130	25	3
Physics	32	7	5

Salaries for engineering and management positions are relatively standard throughout the United States, since these employment groups are particularly mobile. Regional location does not assume the importance that it does for non-professional production workers. In some areas it may be necessary to offer salaries which are higher than the standard for a given function in order to offset the disadvantages of unpleasant climate or living conditions, high cost of living, or isolation. Atlanta has none of these disadvantages.[1/]

A tabulation of 327 questionnaires received from selected Georgia Tech electrical engineering graduates, 1946 to 1957, showed that 91 had

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1/ Cost of living lends itself to easy factual comparison. Atlanta is 19th among the 20 cities included in the latest cost-of-living comparisons published by the U. S. Department of Labor (Autumn 1959). Indices for five major cities (Washington, D. C., = 100) are as follows: Chicago 107; Boston 103; Los Angeles 102; New York 97; Atlanta 92.

considerable interest in relocating in Atlanta. This group included 17 with masters degrees and two with doctorates. Another 136 alumni (21 masters and one doctorate) were interested, but with qualifications. Some 100 (20 with masters) were either not interested or noncommittal.

Atlanta is attractive to professional personnel because it has a pleasant and sunny climate and low home construction costs in addition to the facilities, cosmopolitan attitudes, and cultural life which most large cities can offer.

Opportunities for further education are, of course, an important attraction. Georgia Tech offers 21 graduate courses on the master's level and nine on the doctoral level. Emory University offers masters degrees in 37 fields and doctorates in 20 fields. Seven other colleges and universities in metropolitan Atlanta offer graduate degrees.

The major asset in the Atlanta area's present group of vocational and technical training schools is the Southern Technical Institute, a unit of the Engineering Extension Division of Georgia Tech. Its two-year programs graduate approximately 280 technicians each year in 11 areas of technology, including three options in electrical technology. Located on a new $2,500,000 campus in Marietta, Southern Tech has an enrollment of more than 800.

A survey of the starting salaries of Southern Tech alumni with Associate in Science degrees in Electronics Technology revealed the following:

Year Graduated	Number of Responses	Starting Salaries High	Low	Average
1955	25	$400	$253	$315
1956	38	530	173	355
1957	26	600	216	376
1958	33	446	200	352
1959	37	485	185	365
1960	45	550	200	381

A total of 521 students of electronic technology were graduated between 1949 and the fall of 1960; 48.7% responded to the survey.

Four new vocational-technical schools with courses in electrical and electronic technology will be added to the eight presently in the Atlanta area. Under construction or in advanced planning stages at this writing, these schools will provide training facilities for nearly 10,000 students by 1963 or early 1964.

The 19 degree-granting colleges and universities in metropolitan Atlanta and the area's technical-vocational complex provide business and industry

with a large and continuing supply of well qualified graduates. They further provide business and industry with an almost unlimited choice of courses of study for employed individuals.[1/]

1/ For further information on Atlanta's educational resources see: Lewis, Jerry L. and Clark W. Head, Educational and Training Facilities in Metropolitan Atlanta, Industrial Development Branch, Engineering Experiment Station, Georgia Institute of Technology, March, 1962.

IV. ATLANTA'S AIR TRANSPORTATION FACILITIES

Atlanta cannot claim to be the center of the national market for electronic testing and measuring instruments; the center would probably fall in southern Ohio. But Atlanta is one of the few cities in the United States which can meet this industry's requirements for efficient air transportation to customers located throughout the nation.

The impressive complex of air service from Atlanta has grown, in part, in response to the needs of businessmen who wish to maintain close personal contact with their customers. It is well suited to the electronic instruments industry.

Between the hours of 11:30 in the morning and 1:30 in the afternoon, Atlanta has the busiest airport in the world. Only four cities -- Chicago, Los Angeles, New York and Washington -- had more airline departures than Atlanta in 1961. The city was tenth in the nation in tons of air cargo carried in that year.

Map 1 shows those cities which can be reached from Atlanta without changing planes. A total of 54 cities are served by nonstop flights, 25 with one stop, and 44 with more than one stop. Of the 123 cities indicated, 19 are served by pure jets and another 25 are served by prop jets. Best flight times to 13 "nonstop" cities and Boston are as follows:

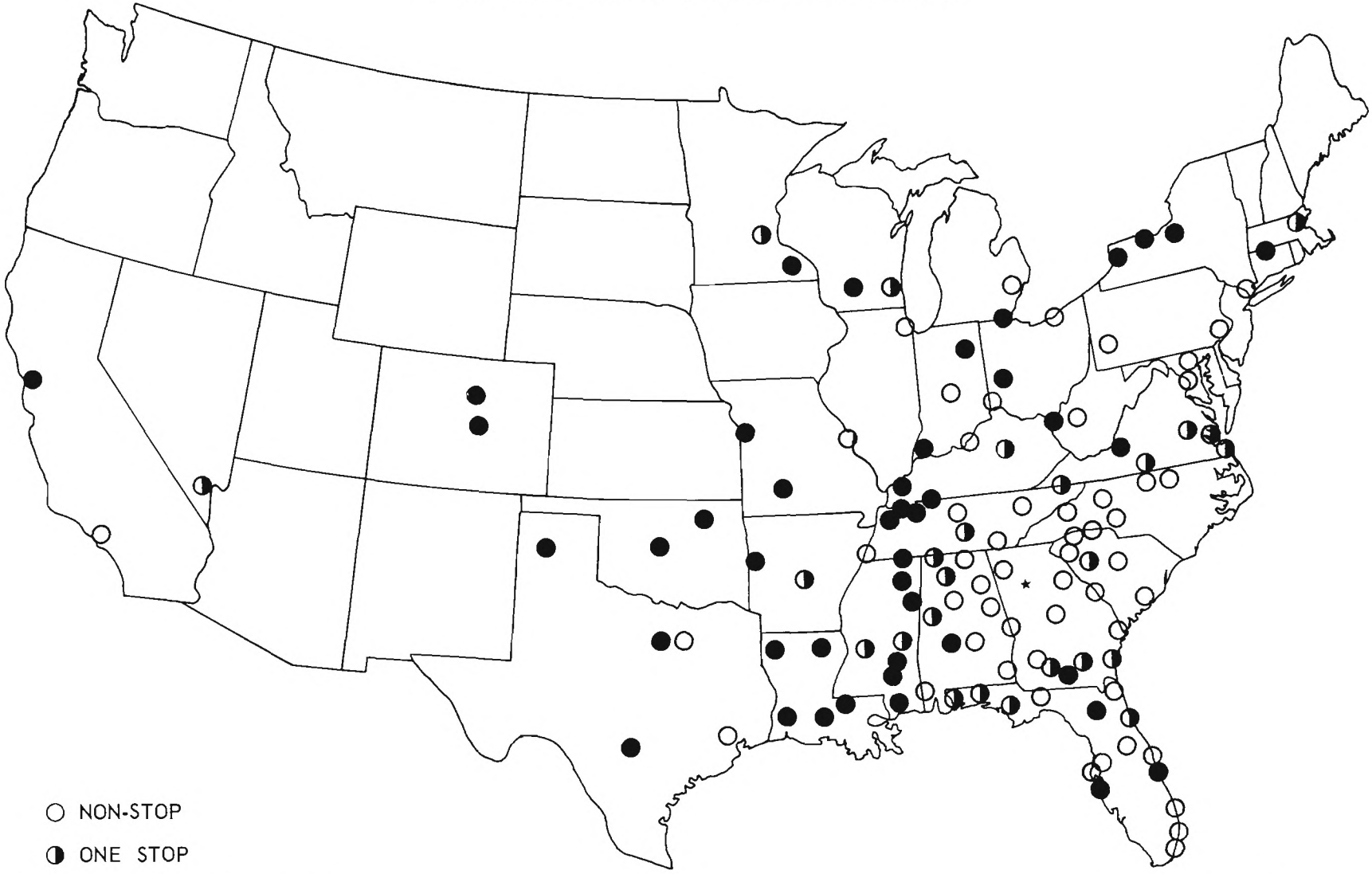
Baltimore-Washington	1 hour - 18 minutes
Boston	3 hours - 13 minutes
Chicago	1 hour - 29 minutes
Cleveland	1 hour - 40 minutes
Dallas	1 hour - 45 minutes
Huntsville	49 minutes
Los Angeles	4 hours - 7 minutes
Miami	1 hour - 26 minutes
New Orleans	1 hour - 2 minutes
New York	1 hour - 39 minutes
Orlando	1 hour - 1 minute
Philadelphia	1 hour - 35 minutes
Pittsburgh	1 hour - 40 minutes

No attempt has been made to describe service obtainable by changing planes, since all cities served by commercial flights can be reached by

doing so. However, it should be noted that many cities not indicated on Map 1 are served by efficient, direct service involving a change of planes. This type of service also provides the quickest time to some cities which are indicated on the map. For example, the quickest flight to San Francisco requires a change of planes in Dallas.

MAP 1

DAILY SINGLE PLANE FLIGHTS FROM ATLANTA



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V. MANUFACTURING IN ATLANTA

Electronic measuring instruments can be manufactured in Atlanta more economically than in the Chicago and New York areas. The greatest savings to an Atlanta manufacturing operation accrue from savings in production wages. In addition, plant construction costs are lower and most raw materials can be obtained from local or nearby sources. Freight costs are only slightly higher from Atlanta to the national markets. Other pertinent factors are Atlanta's lower natural gas and electricity rates.

Labor Costs

The most important single manufacturing input to the electronic measuring instruments industry is production wages. It is in this sector that Atlanta offers the greatest manufacturing cost savings over a Chicago or New York area location. Not only are wages lower, but Atlanta workers produce more dollars of "value added by manufacture"[1/] per dollar of wages than workers in the two other areas. The following comparisons were tabulated from U. S. Bureau of Census statistics:[2/]

Area	Dollars of Value Added Per Dollar of Production Wages
Atlanta	$3.76
Chicago-Northwestern Indiana	$2.90
New York City-Northeastern New Jersey	$2.64

When these ratios are applied to a hypothetical plant at each location, the labor savings in Atlanta can be quantified. A plant with annual shipments of $6 million would typically pay out $2,250,000 for materials and supplies, and the value added by manufacture would be $3,750,000. Production wages at the three locations would be as follows:

1/ "Value added by manufacture" is a Bureau of Census term which means, roughly, value of product shipped less cost of materials. This measure of productivity is not complicated by the fact that some plants simply assemble high cost components and sub-assemblies while other plants produce a complex product from simple materials.

2/ From U. S. Census of Manufactures, 1958. The figures shown are for SIC 361, Electrical Distribution Products. Comparisons cannot be given for SIC 3611, Electrical Testing and Measuring Instruments, because data for the Atlanta Standard Metropolitan Statistical Area are not available. The figure for SIC 3611 in Chicago-northwestern Indiana is $2.63; in New York City-northeastern New Jersey it is $2.43.

	Atlanta	Chicago-Northwestern Indiana	New York-Northeastern New Jersey
Value added	$3,750,000	$3,750,000	$3,750,000
Value added per dollar of wages	$3.76	$2.90	$2.64
Production wages	$997,000	$1,293,000	$1,420,000

A manufacturer selecting Atlanta instead of Chicago would save $296,000 in labor costs annually on sales of $6,000,000--or 4.9% of sales. Since net income before taxes is normally 10% of sales for this industry, profits would be increased by 49%. Selecting Atlanta instead of New York would yield production labor savings of $423,000, or 7.1% of sales of $6,000,000. Profits would be increased by 71%.

Table 3, "Hourly Wage Rates for Atlanta, Georgia--Second Quarter, 1962," allows up-to-date comparisons with specific job rates in other locations. The table is based on a collection of the wage rates of companies manufacturing electronic measuring instruments, machinery and fabricated metal products in the Atlanta area. The specific job titles, such as "Electronic Assembler" and "Class A Maintenance Electrician," are job descriptions used by the companies and are shown with accompanying wage rates.

Construction Costs

F. W. Dodge publishes statistics which allow comparisons of construction costs among eight regions in the United States. Atlanta, Chicago and New York are in separate regions. The cost per square fcot of non-residential construction in these regions is as follows:

City	Dodge Region	Cost per Square Foot
Atlanta	III	$11.72
Chicago	IV	$14.60
New York	II	$16.75

The figures are, of course, too high for manufacturing plants since they include costs for schools and other public buildings. The relative costs are meaningful, however. Leading contractors are building plants in

Table 3

HOURLY WAGE RATES
FOR ATLANTA, GEORGIA--SECOND QUARTER 1962

Job Title	Hourly Rate Range	
Assembly, Semi-skilled		$1.35 - $1.70
Assembly, Precision		1.48 - 2.10
Electronic Assembler	$1.48 - $1.90	
Mechanical Assembler	1.78 - 2.10	
Inspection		1.50 - 2.30
Product Finishing		1.50 - 1.98
Metal Finisher	1.58 - 1.85	
Porcelain Sprayer	1.68 - 1.95	
Metal Polisher	1.68 - 1.95	
Packing		1.50 - 1.90
Warehouse and Shipping		1.50 - 2.10
Material Handlers	1.50 - 1.78	
Stock Clerk	1.65 - 1.85	
Shipping & Receiving Clerk (General)	1.78 - 2.10	
Maintenance		1.88 - 2.80
General Maintenance Mechanic	1.88 - 2.50	
Electrician, Maintenance, (Class A)	2.08 - 2.65	
Technicians		1.88 - 2.75
Laboratory Technicians	1.88 - 2.30	
Electronic Equipment Assembler and Repairman, Class A	2.25 - 2.50	
Electronic Equipment, Test Trouble Shooter	2.50 - 2.75	
Welders		1.68 - 2.58
Welder - Heliarc	1.93 - 2.40	
Sheet Metalworkers		1.88 - 2.60
Electricians, Class A		2.08 - 3.00
Machinist, Class A		2.19 - 2.80
Tool and Die Makers, Class A		2.43 - 3.00
Machine Operators		1.50 - 2.29
Janitor		1.50 - 1.96

the Atlanta area for up to 40% less than the same plants would cost at northern locations. For specific example, one company recently accepted bids for plants built to the same plans at two different locations. The bid in Atlanta was $60,000; on a site in New Jersey, the bid was $95,000. Another comparison under the same conditions found Atlanta costs to be 20% lower than costs in a central Illinois town.

Using the relative costs given by Dodge, if a 60,000 square foot building costs $400,000 in Atlanta, it will cost an estimated $500,000 in Chicago and $570,000 in New York.

Contractors state that the main reasons for lower construction costs in Atlanta are climate and worker productivity. There are more working days under favorable weather conditions. They also state that the attitude of workers--both union and non-union--is superior and permits effective use of new labor-saving tools.

Proximity of Raw Materials

The labor savings which make Atlanta especially attractive as a location for the manufacture of instruments enhance the area's raw material supply position. The South produces a considerable quantity of electron tubes, capacitors, resistors and coils.

In addition, the national suppliers of pressed ceramics and high grade aluminum foil manufacture in Tennessee. Metal mill shapes and forms and high quality castings are produced in Atlanta and nearby southern cities. Table 4 indicates some major bases of supply.

Freight Costs

Electronic testing and measuring instruments are usually shipped by truck. Atlanta's trucking facilities are more than sufficient to fulfill the requirements of an instrument manufacturer based in the area. Seventy regulated fixed-route lines serve Atlanta with daily trucking schedules. Five motor freight carriers offer one-line service to Chicago, two serve the West Coast directly from Atlanta, and 15 connect Atlanta and New York with one-line service.

If a plant producing annual shipments of instruments worth $6 million were selling exclusively to the electronics industry, which is heavily concentrated in the Chicago and New York areas, its annual shipping costs

Table 4

SOME ORIGINAL SOURCES FOR MATERIALS AND SUPPLIES
FOR MANUFACTURE OF ELECTRONIC TESTING AND MEASURING INSTRUMENTS

Item	Source
Electrical grade aluminum foil	Jackson, Tennessee
Pressed ceramics	Chattanooga, Tennessee
Electron tubes	Anniston, Alabama Owensboro, Kentucky
Capacitors, resistors, coils	Huntsville, Alabama Boone, North Carolina Fuquay Springs, North Carolina Gastonia, North Carolina Jonesboro Heights, North Carolina Mars Hill, North Carolina West Jefferson, North Carolina Irmo, South Carolina Pickens, South Carolina Miami, Florida
Transformers	Hollywood, Florida Nashville, Tennessee
Printed circuit board	Atlanta
Carbon steel sheet and shapes	Atlanta Birmingham, Alabama Gadsden, Alabama
Copper wire and cable	Atlanta Carrollton, Georgia Watkinsville, Georgia
Steel castings	Atlanta Birmingham, Alabama Chattanooga, Tennessee
Copper castings	Atlanta Birmingham, Alabama
Aluminum castings	Atlanta
Molded plastics	Atlanta
Metal stampings	Atlanta

would be from $4,000 to $6,000 higher from Atlanta than from Chicago or the New York area. The analysis in Appendix 1 demonstrates that a plant serving such a national market from Atlanta, Chicago or Newark[1/] would have total annual shipping costs from each location as follows:

Atlanta	$33,998.76
Chicago	$27,923.96
Newark	$29,728.98

The shipping cost disadvantage from Atlanta is small even for a market heavily weighted against Atlanta.[2/] Missile and space markets for electronic instruments are, on the other hand, weighted in favor of Atlanta. Aspects of these markets are discussed in the section on southeastern markets.

Other Factors

Atlanta can supply most other manufacturing inputs at less cost than either the Chicago or the New York area.

A hypothetical plant with annual sales of $6,000,000 would consume fuel at a rate of 10,000 therms per month. The monthly bill for equivalent natural gas would be $467 in Atlanta, $741 in Chicago, and $1,262 in Newark, New Jersey.[3/]

Electricity requirements for the model plant would be on the order of 100,000 kwh per month with demand of 500 kw. The bill in Atlanta would be $1,522, in Chicago, $2,009, and in Newark, $1,849.[4/]

Total annual gas and electric utility costs for a plant in Atlanta would be about $9,000 lower than for a similar plant in Chicago and more than $13,000 lower than for a similar plant in Newark. These savings alone are

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1/ Newark was arbitrarily selected to represent the New York City-northeastern New Jersey area.

2/ An important reason for the small variation in shipping cost is the little known fact that Atlanta, Chicago and Newark form an isosceles triangle on a map, with Atlanta to Chicago being the shorter distance by 120 miles. Actual road mileage is as follows:

Atlanta to Chicago - 715 miles
Atlanta to Newark - 854 miles
Chicago to Newark - 832 miles

3/ American Gas Association, A.G.A. Rate Service.

4/ Federal Power Commission, Typical Electric Bills, 1961.

more than sufficient to offset Atlanta's shipping cost disadvantage of $4,000 to $6,000 per year. Estimated annual utility costs at each location are as follows:

Atlanta	$23,900
Chicago	$33,000
Newark	$37,300

Property taxes have not been calculated, since the actual relationship between assessed value and real value cannot be determined from tax laws. The Atlanta firm would, of course, have a lower real value since building construction costs are less.

VI. SOUTHEASTERN MARKETS

Five aspects of the southeastern market for electronic instruments are discussed in this section. They are (1) government spending, (2) electronics manufacturing companies, (3) transportation equipment manufacturers, (4) communications and utilities companies, and (5) other manufacturers.

Throughout the nation, government expenditures for defense and space efforts have pushed the growth of the electronic instruments industry. Much of the southeastern electronics industry has been established because of public sector spending through the installations identified in Map 2, which shows locations of military, National Aeronautics and Space Administration (NASA), and Atomic Energy Commission (AEC) installations, and airframe manufacturers in the Southeast. Government spending is rapidly increasing in the area.

Of all the government's programs, NASA's growing assault on space will have the greatest effect on the southeastern electronics market. About half of its budget of $50 billion in this decade will be used to satisfy electronics requirements (obviously not production items).

The George C. Marshall Space Flight Center at Huntsville, Alabama, will be the largest and richest of NASA's installations.[1/] Its budget of $76.7 million for fiscal 1962 will be topped by an anticipated budget of over a billion dollars in 1963. Officials estimate that half of all expenditures for NASA's Manned Lunar Landing Program will be funneled through Marshall. This means that some $15 to $20 billion will be budgeted for the Center in this decade.

Map 3 shows the locations of manufacturers of electronic components, equipment and systems in six southeastern states. About one quarter of the firms indicated are engaged primarily in electronics research but do some custom manufacturing as well. Most of these manufacturers not connected with government spending programs produce industrial electronics equipment. Among the nationally known companies with important electronics manufacturing facilities in this area are the following:

Electronic Communications, Inc.
Federal Pacific Electric Company
General Electric Company

1/ Daily non-stop flights to Huntsville, Alabama, from Atlanta total 7; from Chicago, 1; from New York, none.

General Instrument Corporation
Magnavox Company
Martin Marietta Corporation
Minneapolis-Honeywell Regulator Company
Radio Corporation of America
Raytheon Company
Sangamo Electric Company
Sperry Rand Corporation
Western Electric Company, Inc.

Each of these companies employs over 1,000 production workers and engineers in its electronics plants in this area; together they employ over 50,000 people in the six states.

Manufacturers of transportation equipment in the Atlanta area are worth noting as markets since the aircraft industry is expected to employ 15,000 people this year and the automotive assembly plants will produce more than 300,000 cars and trucks.

Communications and utility companies offer markets for electronic instruments. The six-state area operates 20% of the radio and TV stations in the United States, has 15% of the installed generating capacity of electrical utilities and industrial plants, and 10% of the central telephone offices. Atlanta is a central office for communications networks which extend far beyond the six-state area.

The market for electronic instruments in industrial control systems is just beginning to grow. Industry observers anticipate widespread use of instruments in the textile and petrochemical industries for manufacturing and quality control. Spectrometers for detecting minute variations in color and electronic equipment capable of inspecting fabric for flaws are examples of instruments which are already in use. The large concentrations of textile manufacturing in the immediate area and petrochemical processing along the Gulf Coast portend a considerable market.

Because shipping costs are less important than production costs and the availability of professional personnel to manufacturers of electronic instruments, established regional markets are not a prime consideration for locating a plant. But growing markets, such as the one surrounding Atlanta, require buyer-seller liaison. This may be an important consideration, depending on the manufacturer's product mix.

MAP 2

LOCATIONS OF MAJOR MILITARY, NASA AND AEC INSTALLATIONS
AND AIRFRAME MANUFACTURERS IN THE SOUTHEAST

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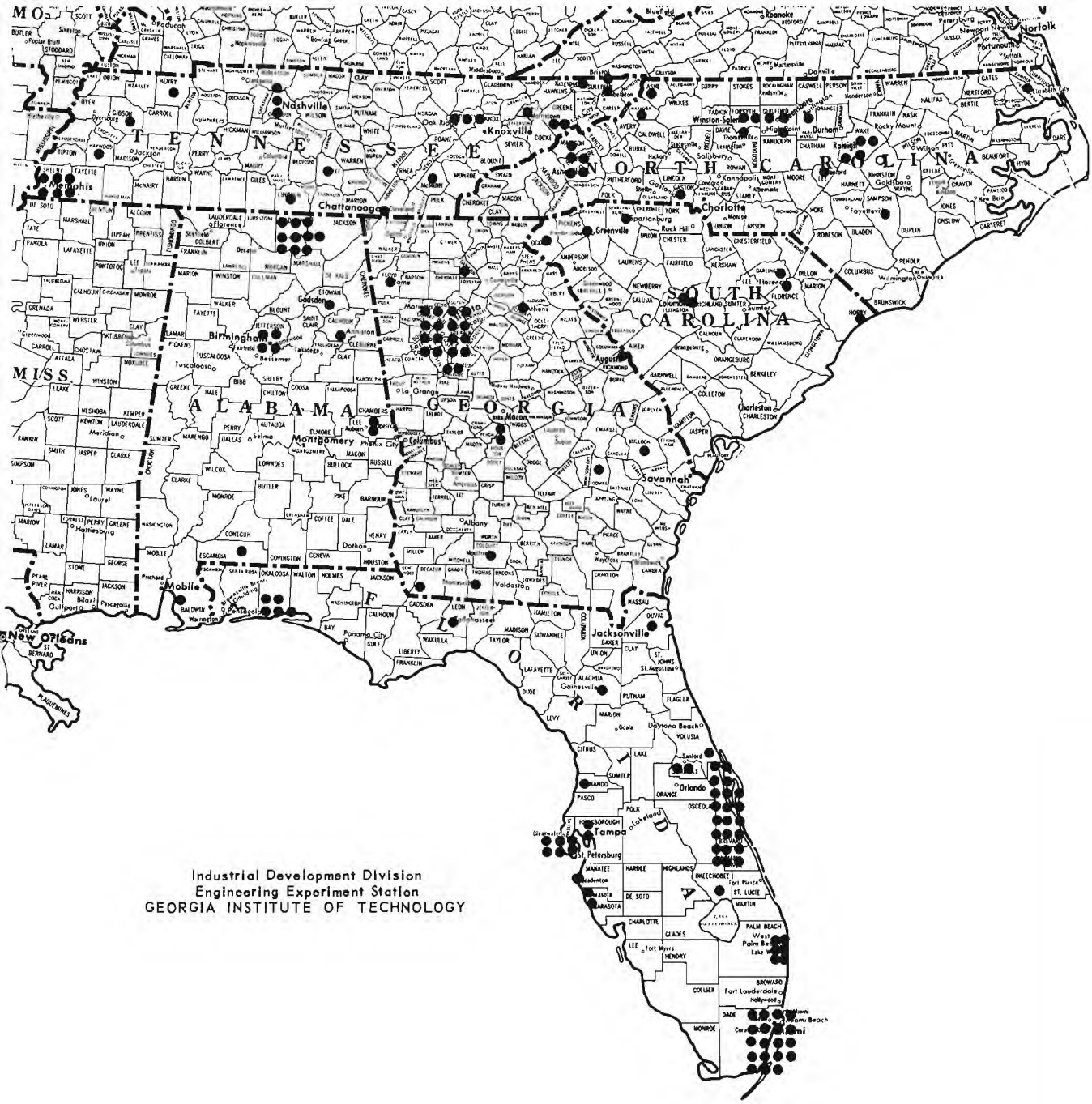
Engineering Experiment Station
GEORGIA INSTITUTE OF TECHNOLOGY

MAP 3

MANUFACTURERS OF ELECTRONIC COMPONENTS, EQUIPMENT AND SYSTEMS
AND PRIVATE ELECTRONICS RESEARCH FACILITIES IN THE SOUTHEAST



Industrial Development Division
Engineering Experiment Station
GEORGIA INSTITUTE OF TECHNOLOGY

Appendix 1

COMPARATIVE ANNUAL SHIPPING COSTS

The purposes of this Appendix are 1) to quantify the relative unimportance of shipping costs for manufacturers of electronic testing and measuring instruments and 2) to demonstrate that Atlanta is as suitable as Chicago or New York for centralized distribution to a national market. To make the latter point as forcible as possible, most of the assumptions made for this analysis were designed to give both Chicago and New York a shipping advantage.

As a basis for analysis, a hypothetical plant was defined as producing annual shipments of electronic testing and measuring instruments valued at $6 million and shipped to customers via common carriers by motor vehicle. The plant's customers were defined as being distributed over 47 cities in proportion to the per cent of the national electronics industry which is found in or near each city. For example, since Los Angeles produces 9.8% of the electronics equipment made in the U. S., it was allocated 9.8% of the instruments produced by the hypothetical plant. The Chicago area produces 9.5% of the electronics equipment made in the U. S., so it was allocated 9.5% of the shipments from the plant. A total of 22.5% of the shipments from the plant was allocated to cities in the New York City-northeastern New Jersey area; and Boston, Lowell and Springfield, Massachusetts together received 8.0% of the plant's shipments. Appendix Table 1 lists the 47 cities selected for the analysis. It also includes other pertinent information described in the following paragraphs.

The product was assigned a value of $10 per pound; annual sales of $6 million, therefore, would represent total shipments of 600,000 pounds. It was assumed that the product could be shipped under NMFC A-6, MF-ICC 4 classification item number 61700, which covers "Electrical Appliances or Instruments, NOI, in inner containers in cloth bags, or in barrels, boxes or crates."

It was further assumed that the average shipment would weigh between 1,000 and 2,000 pounds.[1/] Finally, it was assumed that products shipped to

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1/ If it were assumed that the average shipment would be of truckload weight, annual shipping costs from each location would be as follows:

Atlanta	$22,000
Chicago	$17,700
Newark	$17,400

consumers within the city of origin would be shipped at no cost. Note that Newark, New Jersey, is the shipping origin representing the New York City-northeastern New Jersey area.

Appendix Table 1 shows that if a plant of this description were manufacturing in Atlanta, Chicago and Newark, it would have total annual shipping costs from each location as follows:

Atlanta	$33,998.76
Chicago	$27,923.96
Newark	$29,728.98

A plant located in Chicago--the city with the lowest shipping costs--would save only $6,074.80 a year over a plant located in Atlanta. This savings represents only 0.1% of sales of $6 million. Since the shipping cost differences among the three are so small, it can be concluded that all three locations are suitable for centralized distribution to a national market.

Appendix Table 1

COMPARATIVE SHIPPING COSTS

SHIPMENT TO:	Plant Output Received 1/ (Per cent)	Weight of Shipments Received (Pounds)	FROM ATLANTA LTL Rate (¢/cwt.)	FROM ATLANTA Shipping Cost (Dollars)	FROM CHICAGO LTL Rate (¢/cwt.)	FROM CHICAGO Shipping Cost (Dollars)	FROM NEWARK LTL Rate (¢/cwt.)	FROM NEWARK Shipping Cost (Dollars)
Lowell, Mass.	4.0	24,000	568	1,363.20	500	1,200.00	627	1,504.80
Boston, Mass.	3.0	18,000	559	1,006.20	500	900.00	627	1,128.60
Springfield, Mass.	1.0	6,000	536	321.60	480	288.00	544	326.40
Buffalo, N. Y.	1.0	6,000	497	298.20	391(b)	234.60	374	224.40
Syracuse, N. Y.	1.5	9,000	544	489.60	406	365.40	329	296.10
Rochester, N. Y.	2.0	12,000	522	626.40	379	454.80	360	432.00
Schenectady, N. Y.	0.7	4,200	529	222.18	453	190.26	278	116.76
Yonkers, N. Y.	2.5	15,000	491	736.50	480	720.00	208	312.00
New York, N. Y.	4.0	24,000	518(a)	1,243.20	480	1,152.00	174	417.60
Great Neck, N. Y.	4.0	24,000	511	1,226.40	500	1,200.00	212	508.80
Jamaica, N. Y.	3.5	21,000	518(a)	1,087.80	480	1,008.00	174	365.40
Bridgeport, Conn.	1.0	6,000	522	313.20	487	292.20	391	234.60
Patterson, N. J.	1.0	6,000	518(a)	310.80	480	288.00	165	99.00
Newark, N. J.	7.0	42,000	518(a)	2,175.60	480	2,016.00		
Elizabeth, N. J.	0.5	3,000	518(a)	155.40	480	144.00	157	47.10
Pittsburgh, Pa.	2.5	15,000	461	691.50	379(b)	568.50	386	579.00
Philadelphia, Pa.	4.3	25,800	461	1,189.38	460	1,186.80	254	655.32
Baltimore, Md.	3.5	21,000	428	898.80	446	936.60	302	634.20
Greensboro, N. C.	0.9	5,400	319	172.26	480	259.20	361	194.94
Nashville, Tenn.	0.3	1,800	264	47.52	342	61.56	529	95.22
Atlanta, Ga.	0.5	3,000			451	135.30	491	147.30
Anniston, Ala.	0.4	2,400	204	48.96	436	104.64	514	123.36
Miami, Fla.	0.9	5,400	436	235.44	659	355.86	629	339.66
Detroit, Mich.	1.0	6,000	451	270.60	309(b)	185.40	433	259.80
Cleveland, O.	3.5	21,000	445	934.50	334(b)	701.40	379	795.90
Cincinnati, O.	1.5	9,000	364	327.60	319(b)	287.10	433	389.70
South Bend, Ind.	2.0	12,000	436	523.20	215(b)	258.00	460	552.00
Fort Wayne, Ind.	1.0	6,000	414	248.40	252(b)	151.20	438	262.80
Indianapolis, Inc.	3.5	21,000	386	810.60	272(b)	571.20	453	951.30
Milwaukee, Wis.	2.5	15,000	480	720.00	222(b)	333.00	500	750.00
Waukeegan, Ill.	1.0	6,000	458	274.80	164	98.40	493	295.80
Chicago, Ill	7.0	42,000	451	1,894.20			480	2,016.00
Aurora, Ill.	1.5	9,000	451	405.90	164	147.60	493	443.70
Quincy, Ill.	1.0	6,000	445	267.00	329	197.40	534	320.40
Louisville, Ky.	0.8	4,800	355	170.40	319(b)	153.12	466	223.68
Owensboro, Ky.	0.6	3,600	349	125.64	341(b)	122.76	493	177.48
Minneapolis, Minn.	1.7	10,200	557	568.14	330(c)	343.40(d)	550	561.00
Cedar Rapids, Iowa	0.8	4,800	492	236.16	256(c)	126.08(d)	474	227.52
Omaha, Neb.	0.5	3,000	536	160.80	360(c)	110.00(d)	594	178.20
St. Louis, Mo.	1.6	9,600	407	390.72	309(c)	296.64	520	499.20
Wichita, Kansas	0.5	3,000	521	156.30	411(c)	125.30(d)	637	191.10
Denver, Colo.	0.5	3,000	660	198.00	465	139.50	680	204.00
Dallas, Texas	2.3	13,800	485	669.30	442	609.96	679	937.02
Portland, Oregon	1.0	6,000	1,082	649.20	984	590.40	1,181	708.60
San Francisco, Cal.	3.7	22,200	1,082	2,402.04	984	2,184.48	1,181	2,621.82
Los Angeles, Cal.	9.8	58,800	1,082	6,362.16	984	5,785.92	1,181	6,944.28
Phoenix, Ariz.	0.7	4,200	888	372.96	819	343.98	1,036	435.12
Totals	100.0	600,000		33,998.76		27,923.96		29,728.98

Notes:

(a) Rate includes a to-store-door delivery charge of 27¢/cwt.
(b) Rate effective September 29, 1962.
(c) Surcharge of $1.00 per shipment applies.
(d) Amount includes surcharge of $1.00 per 1,500 pounds.

1/ Figures are per cent of total U. S. shipments of electronic components, equipment and systems. See Appendix 1 text. Based on the 1958 Census of Manufactures and updated with estimates by various industry periodicals.